LIGHT EMITTING DIODE LIGHT SOURCE FOR CURING DENTAL COMPOSITES

PRIORITY: Priority is hereby claimed to United States Provisional Patent Application Serial Number 60/187,899. filed March 8, 2000

I. BACKGROUND OR THE INVENTION

This invention relates to the use of Light Emitting Diodes (LEDs) as a light source for curing dental composite materials.

II. THE BACKGROUND ART

Light Emitting Diodes produce a narrow bandwidth of light output wavelengths. Because dental composite materials require specific and narrow bandwidths of light to polymerize correctly attempts have been made to utilize Light Emitting Diodes in dental curing lights. Furthermore, Light Emitting Diodes produce no infrared energy and, thereby, produce no heat that can be radiated to the patient. Unfortunately, current Light Emitting Diodes, that produce the blue wavelengths requisite to cure dental composites, have a low power output (on the order of 5 milliwatts total blue light output). Furthermore, it is only possible, with current technology, to deliver about 30-40% of the light produced to the dental material. A threshold of about 100 milliwatts is necessary to begin the curing process on most dental composites. Therefore, a number of diodes must be used to achieve output powers that will cure the dental composites. Further complicating the technology is the low overall efficiency of the Light

Emitting Diodes; they are about 6% efficient. Meaning that in order to receive 5 milliwatts in optical energy one must expend 80 milliwatts of electrical energy. The difference in energy in versus optical energy out is dissipated in the form of heat. For every 5 milliwatts of optical energy produced a curing device must dissipate 75 milliwatts worth of heat generated within the Light Emitting Diode.

LumaLite, Inc. of Spring Valley California has invented a Light Emitting Diode curing light, brand named the LumaCure. This light is comprised of 7 Light Emitting Diodes which produce, in ideal circumstances, 35 milliwatts of optical curing energy which is insufficient to hit the threshold of 100 milliwatts and as a result does not cure dental composites. Dental/Medical Diagnostic Systems, Inc. of Wookland Hills, California has invented a Light Emitting Diode curing light that contains over 60 Light Emitting Diodes, however, the device is incapable of dissipating the 4500 milliwatts of thermal energy produced for more than a few seconds, therefore, the device has been found in dentistry to be of little clinical value. Inventor John Kennedy has invented several designs (U.S. Patent Numbers: 5,420,768, / 5,420,768 / 5,233,283) of Light Emitting Diode dental curing lights. None of the designs adequately manage the heat produced by the Light Emitting Diodes and, subsequently, no working models have been introduced to commerce. Inventor J. Martin Osterwalder has invented a Light Emitting Diode dental curing light (U.S. Patent Number: 6,102,696) which contains insufficient numbers of Light Emitting Diodes to hit the dental composite curing threshold and has no provision for dissipating the heat produced by the

Light Emitting Diodes, subsequently, no working models have been introduced to commerce utilizing the design.

III. OBJECTS OF THE INVENTION

It is an object of the invention to provide a Light Emitting Diode (LED) light source for the curing of dental composite materials that has sufficient power to cure the material and adequate heat management structures to avoid heat damage to the curing light itself and the patient.

Additional objects, features and advantages of the invention will become apparent to persons of ordinary skill in the art upon reading the specification in light of the attached drawings.

IV. BRIEF DESCRIPTION OF THE DRAWINGS

Figure 100 depicts the side view and top view on a single Light Emitting Diode.

Figure 200 depicts the side view and top view of a Light Emitting Diode placed in a reflective cup.

Figure 300 depicts ideally light being emitted from the Light Emitting Diode and then being reflected by the reflective angled surfaces of a reflective cup.

Figure 400 depicts realistic light emission from a Light Emitting Diode.

Figure 500 depicts light being generated by a Light Emitting Diode and being reflected by a curved surface reflective cup.

Figure 600 depicts light being generated by a Light Emitting Diode and being reflected to a specific focal point from a curved surface reflective cup.

Figure 700 depicts an array of 144 Light Emitting Diodes placed in 144 separate reflective cups.

Figure 800 depicts a side view of Figure 700 depicting curved reflective surfaces of the individual cups.

Figure 625 depicts a Light Emitting Diode array set in a square cup with an angled reflective surface at the top of the cup. Additional focusing/columniation provided by an array of lenses. Electrical connections of the Light Emitting Diodes is also depicted.

Figure 650 depicts a Light Emitting Diode array placed in curved cups with further focusing/columniation provided by an array of lenses. Electrical connection of the Light Emitting Diodes is also depicted.

Figure 675 depicts a Light Emitting Diode array placed in elliptical curved cups with further focusing/columniation provided by an array of lenses. Electrical connection of the Light Emitting Diodes is also depicted.

Figure 900 depicts an array of 4 Light Emitting Diodes being placed in a single cup with angled reflective walls.

Figure 1000 depicts an array of 12 cups (angled or curved wall) with 4 Light Emitting Diodes in each cup. Further depicted is the electrical isolation of the cup arrays; they are electrically isolated in groups of 4 cups.

Figure 1100 depicts an array of Light Emitting Diodes placed in angle walled cups which are arranged in a curved shape.

Figure 1105 depicts an array of Light Emitting Diodes placed in angled reflective walled or curved reflective walled trenches.

Figure 1110 depicts an array of Light Emitting Diodes that are placed in cups as well as trenches.

Figure 1115 depicts a large array of Light Emitting Diodes that are placed in cups (singularly or in groups) which are electrically isolated from each other in quarters.

Figure 1120 depicts a less dense array of Light Emitting Diodes, in cups and electrically isolated from each other in quarters.

Figure 1130 depicts an array of Light Emitting Diodes comprised of 2 separate types of Light Emitting Diodes which are placed in angle or curved reflective wall trenches. Electrical isolation of the two different types of diodes as well as their electrical connection is also depicted.

Figure 1150 depicts a closely compacted Light Emitting Diode array placed in individual angled or curved reflective wall cups. Quartered electrical isolation is also depicted.

Figure 1155 depicts a less tightly compacted array of Light Emitting Diodes placed in single angled or curved reflective wall cups. Quartered electrical isolation is also depicted.

Figure 1160 depicts a Light Emitting Diode array placed in angled or curved reflective wall trenches. Halved electrical isolation is also depicted.

Figure 1165 depicts a tightly compacted array of Light Emitting Diodes placed in single angled or curved reflective wall cups with no electrical isolation.

Figure 1200 depicts an array of Light Emitting Diodes in reflective walled cups with an array of focusing/columniation lenses depicted.

Figure 1300 depicts an array of Light Emitting Diodes in reflective walled cups with a single lens providing addition focusing/columniation.

Figure 1400 depicts an array of focusing/columniation lenses placed over a single reflective wall cup.

Figure 1500 depicts an array of large focusing/columniation lenses placed over an array of Light Emitting Diodes placed in reflective walled cups.

Figure 1600 depicts an array of Light Emitting Diodes placed in single reflective wall cups sealed with a single optical, non-focusing/collimating window.

Figure 1700 depicts an assembly of a Light Emitting Diode array, a heat transfer device (heat pipe) and a heat dissipating device (heat sink).

Figure 1750 depicts an assembly with electrical connections where the heat transfer/heat sink assembly is also an integral electrical connection (anode).

Figure 1800 depicts water cooling assembly for the Light Emitting Diode array.

Figure 1850 depicts an assembly which first transfers the heat by way of heat pipe and then removes the heat by way of circulation water.

Figure 1900 depicts a machinist drawing for constructing a Light Emitting Diode array for a Light Emitting Diode dental curing light source.

Figure 1910 depicts a machinist drawing for constructing a Light Emitting Diode array for a Light Emitting Diode dental curing light source.

Figure 1920 depicts a machinist drawing for constructing a Light Emitting Diode array for a Light Emitting Diode dental curing light source.

Figure 1930 depicts a machinist drawing for constructing a Light Emitting Diode array for a Light Emitting Diode dental curing light source.

Figure 1940 depicts a machinist drawing for constructing a Light Emitting Diode array for a Light Emitting Diode dental curing light source.

Figure 2000 depicts a machinist drawing for constructing the heat sink (air) for a Light Emitting Diode dental curing light source.

Figure 2010 depicts a machinist drawing for constructing the heat sink (air) for a Light Emitting Diode dental curing light source.

Figure 2020 depicts a machinist drawing for constructing the heat sink (air) for a Light Emitting Diode dental curing light source.

Figure 2030 depicts a machinist drawing for constructing the heat sink (air) for a Light Emitting Diode dental curing light source.

Figure 2100 depicts and assembly drawing to assemble a Light Emitting Diode dental curing light source.

Figure 2110 depicts an assembly drawing to assemble a Light Emitting Diode dental curing light source.

Figure 2200 depicts an electrical schematic to construct a circuit which would modulate the Light Emitting Diode array of a Light Emitting Diode dental curing light source.

Figure 2300 depicts an electrical schematic to construct a circuit which would drive the Light Emitting Diode array of a Light Emitting Diode dental curing light source.

Figure 2400 depicts an electrical schematic to construct a circuit which would charge the batteries of and allow AC (plugged into the wall) operation of a Light Emitting Diode array of a Light Emitting Diode dental curing light source.

Figure 2500 depicts an electrical schematic to construct the AC power supply for a Light Emitting Diode array for a Light Emitting Diode dental curing light source.

Figure 2600 depicts an assembly drawing for the cooling layout of a Light Emitting Diode dental curing light source where the cooling is accomplished by water circulation or phase change heat effussion material.

Figure 2700 depicts an assembly drawing for a Light Emitting Diode dental curing light source.

Figure 2800 depicts and assembly drawing for a Light Emitting Diode dental curing light source.

Figure 2900 depicts an assembly drawing for a Light Emitting Diode light source.

Figure 3000 depicts an assembly drawing for a Light Emitting Diode light source.

V. DETAILED DESCRIPTION OF SOME EMBODIMENTS OF THE INVENTION

The invention first takes the LED as an electronic component without any lenses or wires attached, Figure 100. The LED is essentially a cube with dimensions on the order of 0.250 millimeters, Figure 100. On the top surface is an Anode (101). The bottom surface is metallized and serves as the Cathode and the heat transfer point/medium (102). The LED also contains a layer of semiconductor that is doped with specific materials in specific concentrations to produce the desired wavelength of light (103). Finally, the LED contains a layer of semiconductor substrate (104). When electrical current is passed between the cathode (102) and the anode (101), photons of a particular wavelength (depending on the composition of the materials) are emitted from the doped semiconductor layer (103).

Secondly the invention places the LED or LED array on one side of a flat substrate in all configurations of the invention the substrate is both electrically and thermally conductive. This provides the invention with two unique and superior feature; the heat is immediately removed from the LED and the heat removing/transporting substrate becomes integral with the anode of the LED hence serving as a heat removal device and electrical connection. It is also useful to the invention to place the individual LED into a reflective ‘cup’ which reflects the omnidirectional emitted photons into a single direction, Figure 200. In the simplest of the invention’s cup designs (200) the walls of the cup (201) are manufactured such that they are on a 45 degree angle. Figure 300, for this design the photons are emitted, theoretically and idealistically, out of the top of

the LED and in a horizontal plane (301) from the side of the semiconductor layers (302), the 45 degree side wall (303) would, theoretically and idealistically, reflect the emitted photon and redirect it in one direction 90 degrees from its origin (304). However, in practice, Figure 400, LEDs emit photons (401) in all directions. The invention improves the efficiency of reflection by providing additional cup designs such as a cups containing hemispheric, elliptical or parabolic curve. Figure 500, the elliptical cup (501), because of its curved surfaces reflects omnidirectional photons (502) into one directional photons (503). Furthermore, figure 600, by adjusting the altitude of the LED within the ellipse (601) the invention allows for the omnidirectional photons (602) to be reflected to a specific, predetermine, focal point in space (603). The engineer utilizes the well known optical equation 2/Radius=1/Focal Point + 1/Optical Source to design hemispherical shaped cups and the well know optical equation X^2=4PY to design Parabolic and Elliptical shaped cups. By engineering specific cup shapes and engineering specific placement of the LED within the cup, the invention allows the majority of photons produced by the LED to be placed at a specific point in space where they are needed. Additional cup designs that are useful to the invention (with or without the lenses illustrated) are illustrated in Figures 625, 650, and 675. The specific examples of cup design listed above are not intended to be restrictive to the invention in any way, for instance, a pyramidal (upside down) design as been suggested. The descriptions are simply given to illustrate the potential of specific cup designs. The actual design of the cups would be varied and specific to the application.

Thirdly the invention assembles many LEDs into arrays in order to achieve higher optical output powers than are achieved with a single LED. Figure 800, the invention provides for single LEDs placed in a many cup array. However, the invention is not restricted to this configuration. Figure 900, in the invention the array can be accomplished by placing a number of LEDs within the same cup. Furthermore, the invention also utilized an array of LEDs in each cup coupled with and array of cups, Figure 1000. In figure 1000 there are 4 single LEDs per cup and an array of 16 cups in a circular pattern. The invention is not limited to circular pattern arrays (1000) and square pattern arrays (800), indeed, the pattern of the array is only limited to the potential application. Furthermore, the description of single LEDs in a cup (800) or an array of 4 LEDs in a cup (900) is not meant to restrict the invention to these two descriptions, again, the number of LEDs arrayed per cup is only limited by the application to which it is intended. It is also useful to the invention to manufacture various shapes into which the cups are machined or stamped, Figure 1100. In this configuration (1100) the invention takes advantage of the light reflecting design of the cup and further enhance these properties by positioning the cups themselves in a dish shaped plate. This illustration is not meant to restrict the usefulness of the invention to a flat shaped array of cups (800) and a dish shaped array of cups (1100), on the contrary, it is meant to illustrate the complexity that can be incorporated by the invention in order to suite the particular needs of an application. Figures 1125 and 1150 illustrate additional arrays and 'cup' configurations that are useful to

the invention. Figure 1125 illustrates array configuration in which many LEDs can be placed in arrays that are approximately ½ inch in diameter. 1126, 1127, and 1128 are illustrations of cup designs that are in a 'trench' format, where the sides of the trench are designed in an angled or curved shape. Figure 1150 illustrates array configurations win which many LEDs can be placed in arrays that are approximately 1.5 inches in diameter. 1151 utilizes the trench rather than individual cup design. Again these examples are not meant to be restrictive. They are meant to illustrate some of the many potential array/cup designs that are useful to the invention.

Fourthly, the invention makes use of single lenses, including but not limited to Graded Index of Refraction (GRIN) lenses, lens arrays , including but not limited to Graded Index of Refraction (GRIN) lenses and holographic films , including but not limited to Graded Index of Refraction (GRIN) lenses in order to further process the light and deliver it, in its most useful quantities and qualities, to the specific applications. Figures 625, 650, 675, and 1200, the invention provides for the use of miniature lenses or holographic films (1201) placed directly over the individual cups (1202) forming an array of lenses or holographic films. Figure 1300, the invention also allows for the use of a single lens or holographic film (1301) to be placed over the entire array of cups (1302). Figure 1400, it is also useful to the invention to provide an array of lenses or holographic films (1401). The array of lenses or holographic films could contain many lenses, many films or a combination of lenses and films. Furthermore, it is

useful to the invention to place these arrays over a single cup as illustrated in figure 1400 but it is also useful to the invention, figure 1500, to place a place an array of lenses (1501) and/or holographic film(s) over an array of cups (1502). Whether or not lenses or holographic films or arrays of lenses and/or holographic film(s) are used, it is useful to the invention to seal the LEDs, singularly or in an array, to protect them from environmental conditions that are adverse to their operation. Figure 1600, an appropriate sized piece of anti-reflective (AR) coated optical glass (1601) is placed over the array (1602) and secured with ultraviolet light cured optical adhesive (1603) thus protecting the LEDs from adverse environmental conditions. The discussion and examples listed by way of lenses, holographic films and sealing windows (optical glass) are not intended to restrict the invention to the described scenarios but is rather to illustrate some of the many potential configurations that are useful to the invention. For instances, it has been suggested that micro ball lenses could be used for particular applications. The configuration of lenses, holographic films and sealing optics are only limited to the dictation's of the particular application.

Fifthly, the invention facilitates the removal thermal energy from single LEDs in a flat mounted configuration or in a single cup or from arrays of cups with single LEDs or from arrays of cups that individually contain arrays of LEDs while it maintains electrical insulation and conductivity where appropriate. Cup is defined in the context of this patent as a "shaped hole" in which a single LED or a number of LEDs can be placed. The word cup, as used in this invention, refers

to any configuration that could accept an LED or LEDs. Figures 1120 and 1115 illustrate cups that are circular while Figures 1105, 1110 and 1130 illustrate cups that are formed in a 'trench' configuration. There is no shape constraints to the definition of cup in this invention, however, all cup designs have angled, curved, square or combinations of angled, curved or square walls designed to gather and reflect the photons produced by the LED toward the surface where the photons are needed. Figure 1700, the cup housing may be manufactured from a thermally and electrically conductive material (substrate) such as copper and is plated with optically reflective, thermally conductive and electrically conductive material such as first nickel and then rhodium, or silver(1701). The LED(s) then may be secured to the bottom of the cup(s) using a thermally and electrically conductive adhesive such as silver filled epoxy (1702). The separate sections of LED/cups (1703) are then bonded to a plate made of heat conducting material (substrate) such as aluminum or copper (1710) with a space between the cup sections (1704) to provide electrical isolation. They are bonded to the plate using a thermally conductive but electrically insulating adhesive such as Thermal Epoxy, Electrically Insulating (1705). The LED(s) are then electrically connected by soldiering or conductively bonding the gold wires to the contacts (1706) and connecting them in series to the next electrically isolated cup(s) (1707). A gold wire is then soldiered or bonded to the contact of the last LED(s) (1708) in the series and is taken out to connect to the positive side of the direct current power source (1709). A gold wire is then soldiered or bonded to the cup material of the first LED(s) (1711) in the series and directed toward the negative side of the

direct current power source (1712). Optical adhesive such as Ultra-Violet Activated Optical Adhesive is placed around the tops of the cups (1713), the gold wire leaving the last in the series of LED(s) is then embedded in the optical adhesive (1714) to provide electrical insulation. The optical window (or lenses, holographic films or arrays of lenses and/or holographic films and/or optical windows) (1715) is then position and set into the optical adhesive (1713) and the optical adhesive is cured with an ultra-violet light source. This assembly is then soldiered or bonded (using a thermally conductive adhesive) (1716) to a heat pipe (1717). The heat pipe is then soldiered or bonded to a heat sink (1718) manufactured from a thermally conductive material designed to dissipate heat in to a heat dissipation environment such as aluminum or copper. The heat dissipation environment is an environment that conducts the heat away from the heat sink such as air, water, phase change heat effusion material or a combination of air, water, and phase change heat effusion material. The heat sink is then secured to a chamber (1719) which houses either the direct current power supply, batteries to supply direct current or facilitates connection to an outside direct current power supply. This chamber is then connected to a fan (to move air, water and or phase change heat effusion material (1720) if additional cooling is requisite for the application. This discussion of configuration is not restrictive to the invention. Indeed, the usefulness of the invention for an application, in large part, is due to the inventions ability to be easily configured for specific applications. For instance it has been suggested that rather than having an electrically conductive plating placed on the cup material (1703) that

an optically reflective plastic coating be used instead. In this configuration an electrically conductive substrate would be placed at the bottom of the cup (1702) between the cup and the LED(s), both being secured with electrically conductive epoxy. Another solution would be to mask the bottom of the cup before plastic coating then remove the mask and epoxy the LED in place as described earlier.

The LED(s) need not be wired completely in series. That is to say that you could build a pie shaped (square or round) device that has arrays of LEDs and cups in sections of the pie, figure 1000 illustrates such a scenario or configuration. In figure 1000 there are 4 sections which contain 4 cups each. Each cup contains 4 LEDs. In such a case the negative side of a direct current power source would be attached to one of the sections of cup material. The electrical connectors of each of the sixteen LEDs in this first section would have gold wires soldiered to them and each of these wire would then be soldiered to the next, or second, section of the cup material. The electrical connectors of each of the sixteen LEDs in this second section would have gold wires soldiered to them and each of these wires would then be soldiered to the next (third) section of the cup material. The electrical connectors of each of the sixteen LEDs in the third section would have gold wires soldiered to them and each of these wire would then be soldiered to the next (forth) section of the cup material. The electrical connectors of each of the sixteen LEDs in the forth section would have gold wires soldiered to them and each of these wire would then be directed to the positive side of the direct current power source. In effect and actually this

would produce a series circuit which contains 4 series of 16 LEDs wired in parallel.

The substrate used to manufacture the cups (1703) may be made of the same material used to manufacture the substrate for heat removal (1710) making it an integral one piece assembly, refer to figures 1910, 1920, 1930 and 1940. In this configuration the substrate is an integral heat sink. Electrical isolation is accomplished by bonding a copper conductive sheet using non-conductive epoxy to the top surface of the substrate and wire bonding the LEDs' cathodes to the copper conductive sheet, refer to figure 1930. In this electrical configuration the substrate conducts heat away from the LEDs while conducting electrical current to the anode, electrical current is supplied to the cathode by way of a sheet of copper that has been secured with non-conductive epoxy to the top of the substrate. Furthermore, the design of figure 1130 incorporates two electrical circuits (1133, 1135) which are electrically isolated by machined paths (1134, 1131). This allows two separate types of LEDs (for instance 430 nanometer and 450 nanometer) to be incorporated into the same curing device. This design is incorporated into the proto-type that was constructed and tested and is the subject of the example below.

Another configuration useful to the invention would eliminate the heat pipe and provide a heat dissipation environment directly in the substrate. Refer to figure 1800. 1801 is a heat dissipation environment chamber which allows the heat dissipation environment material (air, water, phase change heat effusion material, or combination thereof) to simple absorb the heat while being stored in

the chamber or may be circulated through the chamber between port (1802, 1803). As is the configuration discussed above the substrates in this configuration can be separated as depicted or may be integral, made of the same material with no separation, providing heat removal, heat dissipation and integral anodic electrical connection. Yet another useful configuration would be to add the heat pipe, refer to figure1850, to move the 'bulky' heat dissipation environment chamber away from the slender, light weight, array assembly. In this configuration heat is immediately transferred from the LEDs through the substrate (1851) (either separated or integral as discussed above), through the heat pipe (1852) and into the heat dissipation environment chamber (1853). The heat dissipation environment chamber (1853) which allows the heat dissipation environment material (air, water, phase change heat effusion material, or combination thereof) to simply absorb the heat while being stored in the chamber or may be circulated through the chamber between port (1854, 1855).

Another configuration would separate the cathode from the anode near the top or anode end of the LEDs. Figures 625, 650, and 675 Illustrate such a configuration. Where 626, 651, and 676 represent an thin film of electrically insulating material, 627, 652, and 677 represent a layer of electrically conductive material such as copper, or copper plated with gold, 628, 653, and 678 represent the wire that would attach the LEDs' anode to the electrically conductive layer. The cathode (629, 654, and 679) is then bonded directly to the heat sink material/configuration (630, 655, and 680) utilizing heat and electrically conductive adhesive producing a unique integral anode heat sink configuration.

The circuits are then separated, where necessary, on the top electrically conductive layer (627, 652, and 677). Figure 1128 illustrates 'trenches' (1131 and 1134) cut through the electrically conductive layer (627,652, and 677) into the electrically insulating material (626, 651, and 676). This configuration (1130) effectively produces two, electrically separated circuits (1133 and 1135). This configuration allows to wire approximately ½ of the LEDs in parallel with each other and the other half of the LEDs in parallel with each other and then wire the halves in series, enabling the designer to manage voltage and current. It also allows the designer to operate two different types of LEDs that have different wavelength output and would require different currents and voltages to drive them optimally.

In some embodiments of the invention it is desired to modulate the light output in order to obtain prescribed post cure physical properties from the composite. For more information on how this accomplished see U. S. Patent Number 6,008,264 which is hereby incorporated by reference.

EXAMPLE: A LIGHT EMITTING DIODE DENTAL CURING LIGHT SOURCE

Obtain a ½ inch diameter by approximately 2 inches in length bar of alloy 110 copper from a source such as MSC Industrial Supply Co., Melville, NY. Obtain a piece of copper clad G10 PCB stock from a source such as Precision Technology, Salt Lake City, Utah. Cut a piece of the copper clad G10 approximately ¾ of an inch in diameter. Soldier the cut piece of G10 to the end of alloy 110 copper bar stock. Have a machine shop such as Axis Machine, Salt

Lake City, Utah machine the assembly according to the specifications in Figures 1900, 1910, 1920, 1930, 1940. Take the machined assembly to a metal plating company such as Quality Plating Company, Salt Lake City, Utah and have the electrically plate the top conductive surface with gold according to mil spec G45204C. Further have them plate the reflective trenches with silver according to mil spec QQS365. Obtain 84-450 nanometer LEDs from Cree, Durham, NC, Part Number: C450CB290E1000, 65-430 nanometer LEDs from Cree, Durham, NC, Part Number: C430CB290E1200. Send the LEDs, Figure 1910 and Figure 1130 with instruction to set and wire bond the 430 nanometer LEDs to 1132 and the 450 nanometer LEDs to 1131 using DM6030HK-SD/H569 Silver Filled Epoxy Paste (Diemat, Inc., Topsfield, MA) to a company like LDX Optronix, Maryville, TN. Have a machine shop such as Axis Machine, Salt Lake City, Utah construct a heat sink according to the specifications in Figures 2000, 2010, 2020, 2030. Obtain a 3/8 inch diameter by 6 inch length of heat pipe from a company such as Thermacore International Inc., Lancaser, PA (Part Number HP-1 0.375 X 6.0). Attach the heat pipe to the heat sink as illustrated in Figures 2100 and 2110 using DM6030HK-SD/H569 Silver Filled Epoxy Paste (Diemat, Inc., Topsfield, MA). Attach the LED array assembly completed by LDX Optronix to the other end of the heat pipe as illustrated in Figures 2100 and 2110. Have a machine shop such as Axis Machine construct a housing out of a plastic material in accordance with the illustration in Figures 2100 and 2110. Have a company such a KWM Electronics Corp., West Jordan, Utah manufacture 4 printed circuit according to the schematic specification in Figures 2200, 2300, 2400 and 2500.

Install the circuits created from Figures 2200 and 2300 into the handle (2101 and 2102 respectively) as illustrated in Figure 2100. Further install the circuit created from Figure 2400 into the battery compartment (2103) as illustrated in Figure 2100. The final circuit is mounted in a small kit box available from any Radio Shack , Nationwide. At household 120 volt AC input cord is installed and an output cord with the corresponding jack on the circuit produced by Figure 2400 is also installed such that the output cord from the External Power Supply Assembly will plug into the circuit created by Figure 2400 which is installed in the battery compartment. This enables the batteries to be recharged or the light to be operated off of household 120 volt AC while the batteries are being recharged. Obtain 8-AA Nickle Metal Hydride batteries from a company such as DigiKey, Theif River Falls,MN and install them in the battery compartment according to the illustration in Figure 2100. Obtain a small 12 volt DC fan from a company such as DigiKey, Theif River Falls, MN and install the fan in the heat dissipation environment chamber (2105) as illustrated in Figure 2100. The device does not necessarily have to have a fan. It could be run with natural air convection providing the cooling, water or a phase change heat effusion material such as sodium Sulfate Decahydrate, Aldrich Chemical Co., Milwaukee, WI. In such a configuration the solid Sodium Sulfate Decahydrate would absorb the heat from the heat pipe and/or heat sink. As it absorbs the heat it converts from a solid to a liquid (phase change) storing the heat. The heat could then be removed by convection or by way of a mechanical linkage, possibly in a 'recharge station' which would convert the sodium Sulfate Decahydrate to a solid

form again. Using any number of phase change hear effusion materials is very useful to the invention in that it eliminates the need for a fan which places additional current demand on the batteries and circuitry, it also adds the noise of the fan to the environment where the light is used. In a configuration where water provides the heat dissipation environment, water could even be stored in the chamber (2115) and re-circulated through the heat sink compartment, making the heat sink compartment and chamber 2115 the entire heat dissipation environment. Of course the water could be simply be pumped through the environment and discarded through an input and output port constructed in the chamber as well.

ADDITIONAL CONFIGURATION EXAMPLES

The basic concepts, designs, and circuitry of this example are not strictly limited to the design of placing the LED array in the immediate vicinity of the tooth. For instance it could be configured such that the LED array is placed in the main housing and the light is delivered by fiber optic or light guide as illustrated in Figure 2600. The LED array (2602) is mounted to the end of a heat pipe (2606) which is then attached to a heat sink (2605), the heat sink being integrated also as the anode for the LEDs as described earlier. The Led Array (2602) produces light which passes through a lens, lens array or halographic film as discussed earlier. The light then passes into the light delivery device (2604) which could be a rigid light guide as portrayed in Figure 2600 or could be a single fiber or a bundle of fibers. The fan compartment (2601) could be filled

with water, a phase change heat effusion material as illustrated in Figure 2600 and discussed earlier or it could contain a fan for cooling.

The basic concepts, designs, and circuitry of this example are certainly not limited to a certain configuration in housing design. Figure 2700 illustrates another potential 'pistol' type design which incorporates the LED array close to the working surface while Figure 2800 illustrates another potential 'pistol' type design which incorporates the LED array within the housing utilizing a light delivery device to get the light to the work surface.

The basic concepts, designs, and circuitry of this example are certainly not limited to an LED array of a certain size and for use in dentistry only. Figure 2900 illustrates a 'pistol' type device that contains an LED array (2901) approximately 3 times the diameter of the example, which would contain approximately 5 times as many LEDs in the array. The LED array uses an integral anode/heat sink configuration where the heat sink (2903) may or may not include a heat pipe (2902). It contains a cooling compartment (2904) which could house a fan, nothing at all, water, or a phase change heat effusion material or a combination thereof. The heat dissipation environment could be stagnant or circulating. It contains a space for circuitry (1905) and for batteries (2906) and could be operated by the electronic presented in schematic detail earlier. A device such as the one illustrated in 2900 could designed for use as a dental curing light, dental bleach activator, forensic light source to name but a few.